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Analyzing the factors that influence Chinese consumers' adoption of the biodiesel: The private vehicles owner's investigating in Beijing

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ABSTRACT

The purpose of the research is to study consumers' attitudes towards biodiesel implementation in China. In the paper, authors analyzed the future trends of diesel demand and revealed the prospects of biodiesel in China. And a comprehensive survey has been conducted for 226 private diesel vehicle owners (drivers) in Beijing. The questionnaire survey method is used to collect information, including respondents' viewpoints on fuels selection, biodiesel quality, biodiesel price and related policies. Furthermore, authors applied Structured Equation Modeling (SEM) to analyze the collected data. The results indicate that the most important factor affecting consumers' selection of biodiesel is price. Other significant factors are policy, government incentives and biodiesel quality. Besides, the results also showed that policy and government incentives could affect the price and quality of biodiesel. These results give rise to serious consideration about consumers' preference for and awareness of biodiesel. The research findings will help government and corporations to understand the consumer's energy consumption behaviors and improve the further implementation for biodiesel in Beijing.

Contents

1. Introduction . . . 200
2. Literature review . . . 200
   2.1. Policy and government incentives . . . 200
   2.2. Quality . . . 201
   2.3. Price . . . 201
3. Material and methods . . . 202
   3.1. Research strategy . . . 202
   3.2. Hypothesis . . . 202
      3.2.1. Price and consumer intention . . . 202
      3.2.2. Policy and government incentives and consumer intention . . . 202
      3.2.3. Quality and consumer intention . . . 202
      3.2.4. Policy and government incentives and quality . . . 203
      3.2.5. Policy and government incentives and price . . . 203
   3.3. Data collection . . . 203
4. Results and discussion . . . 203
   4.1. Exploratory factor analysis . . . 203
   4.2. Confirmatory factor analysis . . . 203
   4.3. Construct reliability analysis . . . 205
   4.4. Results of hypothesis testing . . . 205
5. Conclusion . . . 205
Acknowledgment . . . 206
References . . . 206

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1. Introduction

With the rapid increase of energy demand in the world, the price of fossil fuel has risen sharply. Besides, the global climate change has become a serious problem. Under the circumstances, biodiesel developed rapidly as a new type of green energy which is clean and sustainable. And many scholars and research institutions have conducted a lot of research on biodiesel. As a kind of significant fuel, biodiesel is available, renewable, environment friendly and has higher combustion efficiency [1,2]. "Global Biodiesel Market Analysis and Forecasts to 2020" issued on April 6, 2010 reported that in the first decade of 21st century, the compound annual growth rate of production in global biodiesel market is 41.9%, and the production is expected to increase continually in the second decade, representing a CAGR of 10%. In order to improve energy security and to meet the rising energy consumption, the biodiesel market is expected to produce 45,219 million liters of biodiesel in 2020. At present, the European Union is the world's largest biodiesel producer, accounting for 53% of all biodiesel productions in 2010, followed by the United States. In recent years, emerging markets for biodiesel are expected to develop in China, India, and Brazil [3–5].

China's economy has developed quite fast in recent years; thus the demand of diesel in China has increased a lot. According to the latest data, the annual diesel consumption of China reached 124,329 million tons in 2007, and the number increased to 169,721 million tons in 2012. Scholars estimated that the diesel consumption in China will go up to 210 million tons in 2020 [6]. However, with the dwindling of fossil fuel reserves and increased difficulties in drilling, domestic diesel annual output is difficult to meet the rising consumption of diesel in China. Moreover, the toxic emissions and particulate matter generated from fossil diesel combustion have caused serious air pollution and directly affected citizens' living condition, just like the PM 2.5 pollution in Beijing. As the result, it is impending to promote alternative energy to relieve all of these problems. The development of biodiesel industry conforms to the trend of the times, which can help to reduce dependency on oil and combat air pollution.

As an emerging biodiesel market, China has lagged far behind U.S. and European countries, which might be explained from the following aspects. First of all, the development of biodiesel industry is still in its infancy in China. The promotion for biodiesel is not enough; thus people have limited knowledge about the quality, price and relevant attributes of biodiesel [7]. Second, profit earned from biodiesel is quite low. Due to the rising expense of materials and low sales price, a lot of biodiesel manufactures operate in deficit. Last but not least, biodiesel industry could not enjoy enough support of the government. Since Chinese government has not provided powerful subsidy policy, companies are difficult to develop. Fortunately, government of China have set ambitious targets for the promotion of biodiesel in recent years, namely, achieving 1.93 million tons biodiesel production in 2020, which is 5.75 times as large as the present production (0.34 million tons biodiesel) [8]. If Chinese government wants to achieve the goal, an important issue should be discussed, which refers to the major factors affecting biodiesel's promotion. Therefore, the authors will concentrate on these issues in the study and hope that the research result can present effective strategies for biodiesel corporations and further promote the development of biodiesel in China.

In present studies, most researches focused on the progress, technical analysis and material selection analysis of biodiesel while marketing is omitted. Therefore, this paper adopted the method of questionnaire survey to research the target consumers who has known about biodiesel. Then authors use the Structured Equation Modeling (SEM) to find out the major factors influencing people to adopt biodiesel. Finally, authors will present development strategies of biodiesel industry and give certain suggestions based on the research findings.

SEM is a statistical technique for testing and estimating causal relations through the use of combination of statistical data and qualitative assumptions. SEM has been widely used in healthcare, logistics, information management, banking, psychology, marketing and tourism management. A structural equation model has become a preferred data analysis method for empirical research. Following the trend in empirical research, authors adopt SEM to analyze the first-hand data from survey.

2. Literature review

Biodiesel is considered as one of the alternative fuels which can help to protect the environment and improve energy safety. A fair number of scholars have done relative studies on biodiesel. Most of them believe that regulation and technology are major factors to motivate consumers to use biodiesel. However, private car owners have considerable freedom to choose different types of diesel in China. Therefore, it is not only important to know about biodiesel supply, but also significant to understand consumer purchasing intention. Thus, authors review the literature related to biodiesel from the perception of consumers.

2.1. Policy and government incentives

Government's policy for production is decisive to the popularization of biodiesel [9]. Due to the profitableness of bio-fuel production [10], policy such as government procurement, subsidies on the cultivation of non-food crops and exemption from tax [11,12] will directly promote the development of biodiesel industry. Many countries in the world have adopted various policy initiatives, specific legislation to regulate and improve the use of biodiesel.

In the European Union (EU, the world's largest biodiesel manufacturer), the increasing interest and importance of biodiesel have been recognized by the governments of many countries; thus they have issued biodiesel-related policies [13]. (1) Government procurement—the empirical results done in Spain showed that the procurement of buses that use biodiesel can help to increase the biodiesel consumption [14]. (2) Direct financial subsidy from the governments—the subsidy focuses on start-up of processing enterprises, technology research and raw material production. According to the EU reform in 2003, farmers who grow crops for energy are able to enjoy the "carbon credits" subsidy, namely the policy of 45 euro cents per hectare [15]. (3) Exemption from value added tax—EU allows member countries to apply differentiated tax rates in order to promote bio-fuels. And Europe usually executes high energy tax on conventional fuel.

In the United States, government takes similar measures to support their biodiesel industry. First, various kinds of subsidies were provided to biodiesel research institution and manufactories. Second, Koplow [16] estimated that the tax revenue due to biodiesel exemption would reach almost $1.4 billion US dollar to encourage the application of biodiesel. In addition, American government enlarges sales channels to boost biodiesel consumption. For example, the official vehicles of nearly 350 departments, including the US Army, Park Service and municipal authorities have used biodiesel.

Asia is an emerging market of bio-fuel and the increase in the use of biodiesel also benefits from government supports. In India, Ministry of Rural Development calls on local governments to publicize biodiesel fuel and Oil Ministry is responsible for proposing economic and political strategies to the comprehensive

promotion of biodiesel in 2012 [17]. The government has provided fiscal incentives for biodiesel production and reduces 4% of the central excise tax [10]. Biodiesel producers in Malaysia are eligible for financial incentives. The policy allows at least 70% tax reduction on the earning obtained from biodiesel production for five years. However, in China, supports from the government and incentive mechanisms specific to biodiesel are obviously deficient. Financial policy and demonstration projects have not been practiced yet; thus the public is unaware of relevant policy and the confidence of consumers about biodiesel has not been built [18].

2.2. Quality

Quality and safety standard are pivotal factors that people will consider about when they choose vehicle fuel. There are several advantages of biodiesel which absorb consumers to use it instead of conventional diesel. (1) Biodiesel prolongs engine life and reduces the need for maintenance (biodiesel has better lubricating qualities than fossil diesel) and it is much safer [16]. (2) Biodiesel is better than conventional diesel in aspects of sulfur content, flash point, aromatic content and biodegradability [19]. (3) Biodiesel is non-flammable and cleaner. It reduces tailpipe emissions, visible smoke and noxious fumes and odors [20]. In biodiesel–diesel fuel mixture, biodiesel accounts for more than 20%, so the harmful emissions are significantly reduced. This fact acts as a powerful stimulation for the usage and production of biodiesel [21].

Safety is of paramount consideration when consumers use biodiesel. A poor quality of biodiesel is possible to lead to the engine failure, thus threaten passage safety [22]. According to the research of Atadashi et al. [23], biodiesel of high purity and quality is necessary to avoid compression ignition engine problems, which is crucial for the successful application and future promotion of biodiesel. Tang's team did a survey, in which the biodiesel blends were sold at 24 retail stations. The result shows that the overall quality appears to be acceptable but some consumers complain about filter plugging and cold start problems. The result indicates that the quality problems of biodiesel blends do exist and they will influence people's purchase of biodiesel [24]. Van de Velde et al. [25] investigated the perception of Belgian consumers with respect to the use of bio-fuels and identified four consumer segments based on the perceived importance of different fuel characteristics. They found if companies want to convince the performance-oriented and environment-oriented consumers to use bio-fuels, they must supply information about biodiesel's quality and performance standards.

The lack of widely accepted quality standards for biodiesel is problematic in the world [26]. Since biodiesel is produced from varying origins and qualities, it is necessary to install a standard of fuel quality in order to guarantee an engine performance without any difficulties and ensure better criteria of biodiesel for successful commercialization of biodiesel [27]. Different scholars emphasize the significance of quality standards for the future promotion of the bio-fuel market; they proved that standards provide the opportunity to install and build confidence in the end user [28,29]. Currently, in terms of biodiesel, the European Standard DIN EN 14214 and American Standard for Testing Materials (ASTM6751-3) have been developed, which ensure the quality of biodiesel, thus guarantee its purchase [15]. Most of the countries in East Asia Summit have established their own national biodiesel fuel standards to minimize problems with engines arising from using biodiesel [22]. However, these quality standards of biodiesel differ from country to country [30]. Different standards could lead to troubles in some countries and also become obstacles to trade among countries. Thus, in recent years the East Asia policy-makers decided to unify the biodiesel fuel standard and published regional benchmark standard to expand the market of biodiesel industry [27]. In China, Biodiesel Blend Stock for diesel engine fuels (BD100) (GB/T20828-2007) is the only standard implemented [31]. But the enforceable quality standards for widely used biodiesels B5 and B10 are absent; thus the uneven biodiesel quality standard is one of the key constraints to attract consumers [18]. From the above, uniform biodiesel quality standard plays an important role in promoting biodiesel in China in a long run.

2.3. Price

Price is determined by demand and it would be considered initially when people choose vehicle fuel. Reducing prices can be used to stimulate particular economic sectors or segments of the population [9]. Wong et al. [32] already found that high prices for green technologies, and in particular fuels that do not result in savings for consumers, will cause trouble for the sale of biodiesel. Bomb et al. [33] also pointed that equal price amongst competing fuel types is a necessary condition for the expansion of the biodiesel market. Van Vliet et al. [25] have made a model to find the influencing factors of adoption of alternative fuels by 11 distinct subpopulations of motorists. The model is for the production of six transport fuels and six fuels blends from six feedstocks through 13 different production chains. The researchers have found that price is the major selection criterion for motorists

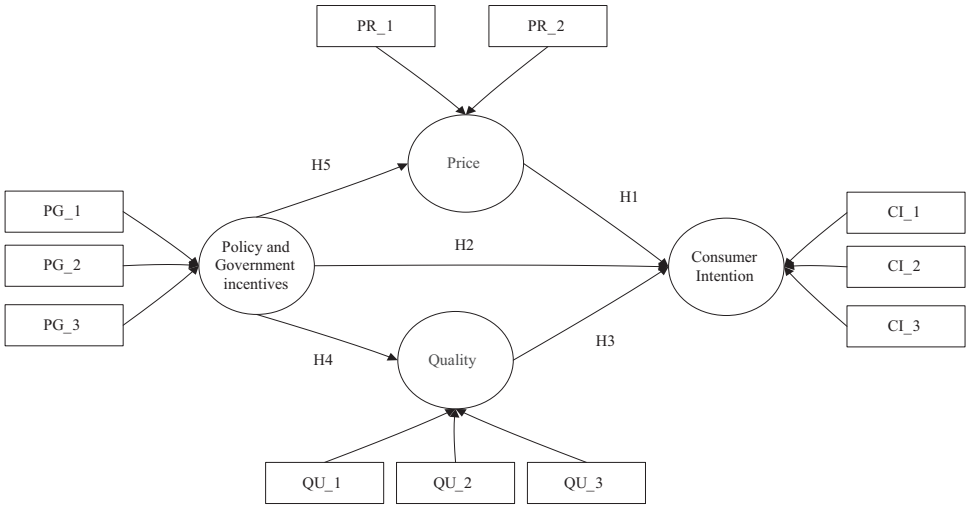

Fig. 1. The proposed model and hypotheses of consumer intention in adopting biodiesel.

in fuel choice, but other factors also have impacts if the prices are similar. Michael Popp et al. [34] investigated American and European consumers and concluded that the relative prices of certain fuel (e.g. gasoline vs. diesel vs. bio-fuel) are determinants of consumer interest in purchasing a new fuel.

In most western countries, biodiesel is two times more expensive than petrol diesel because of the high cost in feedstock. High price is the major disadvantage of biodiesel [35]; thus to guarantee the consumption of biodiesel, the fiscal policy support is indispensible to maintain an attractive price [17]. Huang and Wu [36] studied the situation in Taiwan in their article. The present price of biodiesel compared to fossil diesel is still uncompetitive due to the high cost of raw materials; thus the two researchers suggest that government should provide necessary subsidies and exempt the related taxes on biodiesel to improve its market competitiveness. They believe that price is a crucial factor in the promotion process; thus more attention should be paid on it. In current China, because of the sufficient raw material of biodiesel reserves, the price of biodiesel is competitive in China. However, due to the tendency of rising materials price and various kinds of cost, the price tend to be fluctuating. According to the Zhang et al. [37] investigation in Nanjing to analyze Chinese consumer's perception for bio-fuel implementation, it can be concluded that passenger vehicle drivers focus on the price and performance of fuel. Therefore, it can also prove that biodiesel's price is an important factor for its development in China.

In China, most previous studies focused on biodiesel implementation, conversion technologies and land resources while few of them related to Chinese consumers' awareness of bio-fuel. Thus, related study of particular consumers' perception about biodiesel can hardly be found in China.

3. Material and methods

3.1. Research strategy

Consumers' intention is one of most important factors affecting the development of biodiesel in China. From the literature review, authors found that biodiesel price, quality, policy and government incentives are significant issues that will influence consumers' intention to use biodiesel. So we could use these three dimensions to measure consumers' intention. And there exists virtually no research examining customers' behavioral intention to adopt biodiesel by Structured Equation Modeling.

Most of them selected SEM to be the statistical tool. Davis [38] used SEM, according to which, "users' adoption of computer system" depends on their "behavioral intention to use". Cheng et al. [39] used SEM to understand customers' intention to adopt Internet banking. Lu et al. [40] adopted SEM to reveal intention of shippers to use Internet services in liner shipping. Kelly [41] employed SEM to calculate the magnitude and significance of explanatory variables on residential energy consumption. So the SEM is a suitable statistical tool to reveal consumers' intention.

3.2. Hypothesis

The research framework of this study, based on consumer intention to adopt biodiesel for daily fuel, is shown in Fig. 1. The theory and research hypotheses of this study are presented with referring to the Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB). TRA is a widely studied model from social psychology that is concerned with the determinants of consciously intended behaviors [42]. TAM was proposed by Davis [38] as an extension of TRA. TAM adopts TRA model's causal relationships to explain an individual's internet service acceptance behavior. TPB is another extension of TRA, which provides a useful tool to predict a wide range of behaviors in many different studies [43,44].

Taking into account the previous considerations, the relationship among quality, price, consumer intention, policy and government incentives is evident in personal data handling and should be examined in greater detail. With the aim of testing the connections in the biodiesel promotion, the following hypotheses are proposed.

3.2.1. Price and consumer intention

It is assumed that biodiesel price will influence consumer intention. Specifically speaking, high biodiesel price makes customers not choose biodiesel as daily fuel. Wong et al. [32] have already found that high prices for green technologies, and in particular fuels that do not result in savings for consumers, are very hard to sell.

H1. There will be a positive relationship between price and consumer intention.

3.2.2. Policy and government incentives and consumer intention

China is an emerging market of bio-fuel. The confidence of consumers about biodiesel has not been built. The government of China publicizes biodiesel fuel, which will increase consumer's faith and enhance the purchase intention of consumers.

H2. There will be a positive relationship between policy and government incentives and consumer intention.

3.2.3. Quality and consumer intention

Quality is the pivotal factor that people will consider about when they choose the vehicle fuel. A poor quality of biodiesel fuel

Table 1
The respondents' viewpoints about adopt biodiesel.

	Strongly disagree (%)	Disagree (%)	Slightly disagree (%)	Neutral (%)	Slightly agree (%)	Agree (%)	Strongly agree (%)
Policy and government incentives							
Requirement by law or regulation	0.9	1.8	4.9	8.0	20.4	13.7	50.4
The government advertises biodiesel fuel	0	0.4	6.2	10.2	21.7	19.0	42.5
Tax incentives for purchasing alternative fuel	0	2.7	4.4	8.4	21.7	21.2	41.6
Price							
Attraction of biodiesel price	0	6.2	4.9	12.4	23.9	19.0	33.6
Engine modification and maintenance cost	0.4	1.3	12.4	15.5	23.0	17.3	30.1
Quality							
Biodiesel quality standard	20.4	6.6	16.8	25.7	17.7	6.6	6.2
Biodiesel performance	10.6	3.1	20.8	23.9	19.5	8.4	13.7
Engine performances	17.3	10.2	16.4	23.0	17.3	8.0	8.0
Consumer intention							
Trying on biodiesel	0	2.2	6.2	16.8	20.4	16.8	37.6
Change consumer habits	0.9	0.4	8.8	15.5	20.4	13.7	40.3
Recommend to friends	0	4.0	8.8	16.4	12.4	18.1	40.3

may lead to the engine failure and threaten passage safety. So quality of biodiesel will affect consumer intention.

H3. There will be a positive relationship between quality and consumer intention.

3.2.4. Policy and government incentives and quality

In China, Biodiesel Blend Stock for diesel engine fuels is the only standard implemented [31]. But the enforceable quality standards for biodiesels B5 and B10 are absent; thus the uneven biodiesel quality standard is one important problem for monitoring quality of biodiesel. This assumes that more biodiesel relative policy will improve bio-fuel quality.

H4. There will be a positive relationship between policy and government incentives and quality.

3.2.5. Policy and government incentives and price

Price is determined by demand. Fuel's price would be considered initially when people choose vehicle fuel. Some policy of the government will influence biodiesel's price, including government procurement, subsidy for the cultivation of non-food crops and exemption from the tax. This assumes that policy and government incentives will decrease the price of biodiesel.

H5. There will be a positive relationship between policy and government incentives and price.

3.3. Data collection

The design of the initial questionnaire was confirmed by experts and scholars in the university and then practiced through in-depth discussions with private diesel vehicle owners. Pre-tests of the initial 18-item questionnaire were carried out with 30 private diesel vehicle owners to improve the questionnaire. The resulting modified 11-item pool was presented to private diesel vehicle owners in the survey. Respondents were asked about their attitude towards biodiesel when answering the questionnaire.

In Beijing, there are 200 thousand diesel cars and 600 diesel gas station (the data comes from Beijing Traffic Management Bureau and Beijing Administration for industry and commerce). The authors contacted CNPC and Sinopec Beijing Marketing Company and then used excel to randomly select 20 gas stations from 560 gas stations name list in the area of Beijing. And authors got 397 volunteer sampling from 20 gas stations, thus generated 226 (56.93%) fully usable questionnaires. The questionnaires of collection are non-random samples. So authors compared some of the survey results with available information about the population. The results turn to be very similar. As a consequence, authors may conclude that our sample represents the profile of the average private diesel vehicle owners.

In this study, authors use the adapted question items as the instrument to measure the respective constructs below, using a 7-point Likert scale for each item (with 1=strongly disagree, 2=disagree, 3=slightly disagree, 4=neutral, 5=slightly agree, 6=agree, and 7=strongly agree). The survey results are shown in Table 1.

Table 2
Summary of construct reliability, convergent validity and factor loadings.

Factors	Factor loading	Cronbach alpha	Variance explained (%) 79.211%	Construct Reliability (CR)	AVE
Consumer intention		0.823	18.727	0.8499	0.654
CI_1	0.638				
CI_2	0.747				
CI_3	0.775				
Policy and government incentives		0.839	19.432	0.8582	0.6690
PG_1	0.836				
PG_2	0.715				
PG_3	0.599				
Quality		0.855	21.505	0.8648	0.6854
QU_1	0.918				
QU_2	0.778				
QU_3	0.918				
Price		0.823	19.547	0.8244	0.7015
PR_1	0.792				
PR_2	0.781				

Used SPSS Principal Axis Factoring extraction with Equamax rotation method.

4. Results and discussion

4.1. Exploratory factor analysis

An exploratory factor analysis using SPSS 17 was conducted on all the data. The rotated factor matrix, resulting from an Equamax rotated principal axis factor extraction of the independent variables using the 1.0 eigenvalue cut-off criterion (see Table 2), indicates that 11 factors emerged and also reports their factor loadings.

The data were tested through the use of the SPSS 17 Exploratory Factor Analysis to evaluate the Cronbach alpha (Cronbach alpha is a coefficient of internal consistency. It is commonly used as an estimate of the reliability of a psychometric test for a sample of examinees). The Cronbach alpha indicator is the most frequently used test in assessing reliability (reliability in quantitative research can be translated into legitimate corresponding operations for qualitative research). Some scholars consider that it underestimates reliability. Consequently, the use of composite reliability has been suggested [45], using a cut-off value of 0.7. The results show the value for perceived consumer intention's Cronbach alpha is 0.823; the value for policy and government incentive's Cronbach alpha is 0.839; the value for quality's Cronbach alpha is 0.855; the value for price's Cronbach alpha is 0.823. This is satisfactory (a cut-off value of 0.7). Each item was evaluated respectively to ensure convergent validity and item reliability. And all factor loadings (factor loading is a statistical method used to describe variability among observed, correlated variables in terms of a potentially lower number of unobserved variables called factors) were larger than 0.5, representing an acceptable significant level of internal validity. The factor loadings ranged from 0.638 to 0.775 for consumer intention, from 0.599 to 0.836 for policy and government incentives, from 0.778 to 0.918 for quality and from 0.781 to 0.792 for price. All factor loadings were of acceptable significant; all 11 items were retained for further analysis (see Table 2).

4.2. Confirmatory factor analysis

Authors developed Structural Equations Modeling (SEM), in which the objective of test is the proposed hypotheses (Fig. 2). According to the research result, authors observed that the hypothesis was supported at the 0.05 level. Model fit was acceptable (Chi-square $=100.454$ df$=37$, $p<0.05$, normed Chi-square$=2.715$) From calculation, the author obtained the SEM model fit indexes, and listed the processes in the following paragraphs.

The GFI (Goodness of Fit Index) was devised by Joreskog and Sorbom [46] for MI and UI is estimation, and generalized to other estimation criteria by Tanaka and Huba [47]. The GFI is given by

$$\mathrm{GFI} = 1 - \frac{\widehat{F}}{\widehat{F}_b} \quad (1)$$

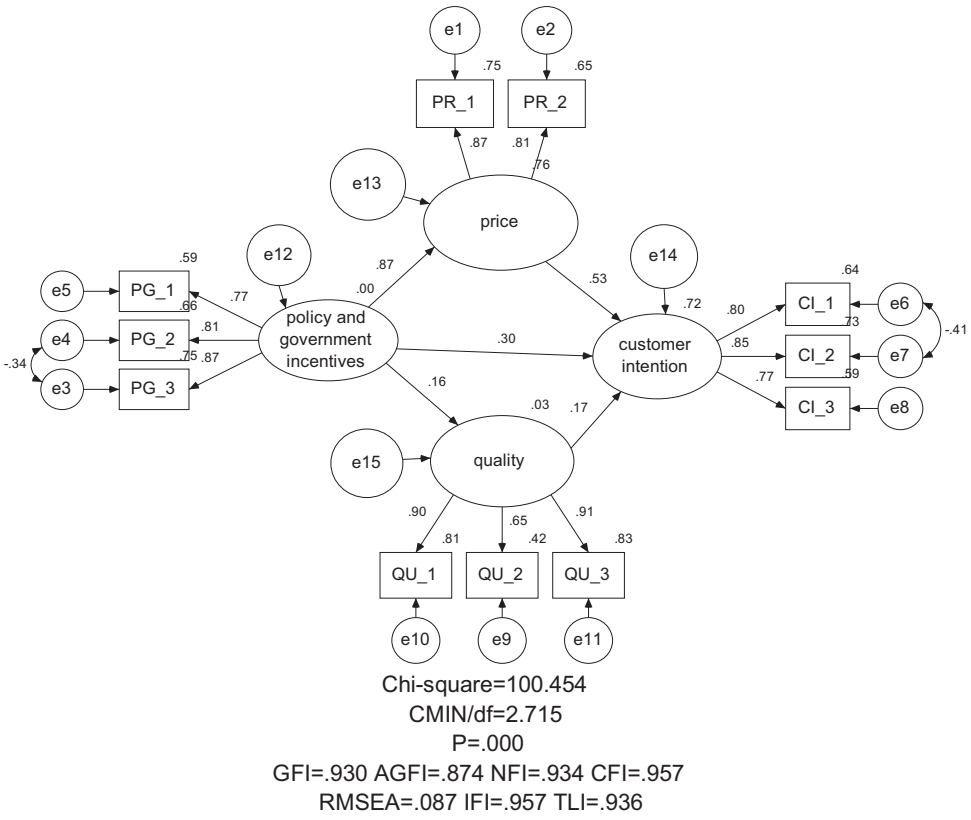

Fig. 2. Structural equation results—consumer intention model in adopting biodiesel.

where $\widehat{F}$ is the minimum value of the discrepancy function and $\widehat{F}_b$ is obtained by evaluating F with $\Sigma^{(g)}=0$, $g=1, 2,\ldots,G$. An exception has to be made for maximum likelihood estimation, since (D2) is not defined for $\Sigma^{(g)}=0$. For the purpose of computing GFI in the case of maximum likelihood estimation, $f(\Sigma^{(g)}; S^{(g)})$ is calculated as follows:

$$f\left(\Sigma^{(g)}; S^{(g)}\right) = \frac{1}{2}\,\mathrm{tr}\left[K^{(g)^{-1}}(S^{(g)} - \Sigma^{(g)})\right]^2 \tag{2}$$

with $K^{(g)} = \Sigma^{(g)}(\widehat{\gamma}_{ML})$, where $\widehat{\gamma}_{ML}$ is the maximum likelihood estimate of γ. Through using formulas (1) and (2), the author calculated that the model's GFI is 0.930.

The AGFI (Adjusted Goodness of Fit Index) takes into account the degree of freedom available for testing the model. It is given by

$$\mathrm{AGFI} = 1-(1-\mathrm{GFI})\frac{d_b}{d} \tag{3}$$

where

$$d_b = \sum_{g=1}^{G} p^{*(g)} \tag{4}$$

From the use of formulas (3) and (4), the author concluded that the model's AGFI value is 0.874.

The Bentler–Bonett normed [48] fit index (NFI), or Δ_1 in the notation of Bollen [49] can be written

$$\mathrm{NFI} = \Delta_1 = 1-\frac{\widehat{C}}{\widehat{C}_b} = 1-\frac{\widehat{F}}{\widehat{F}_b} \tag{5}$$

where $\widehat{C} = n\widehat{F}$ is the minimum discrepancy of the model being evaluated and $\widehat{C}_b = n\widehat{F}_b$ is the minimum discrepancy of the baseline model. By using formula (5), the author calculated that the model's NFI is 0.934.

Table 3
Overall model fit indices of the research model.

Fit statistic	Suggested	Obtained
Chi-square		100.454
df		37
Chi-square significance	$P<$ or $=0.05$	0.000
Chi-square/df	<3	2.715
GFI	>0.90	0.930
AGFI	>0.80	0.874
NFI	>0.90	0.934
CFI	>0.90	0.957
RMSEA	<0.1	0.087

The Comparative Fit Index [50] (CFI) is given by

$$\mathrm{CFI} = 1\frac{\max(\widehat{C}-d,\ 0)}{\max(\widehat{C}_b-d_b,\ 0)} = 1-\frac{\mathrm{NCP}}{\mathrm{NCP}_b} \tag{6}$$

where $\widehat{C}$, d, and NCP are the discrepancy, the degrees of freedom and the noncentrality parameter estimate for the model being evaluated, and $\widehat{C}_b d_b$ and NCP_b are the discrepancy, the degrees of freedom and the noncentrality parameter estimate for the baseline model, respectively. Through the use of formula (6), the author calculated that the model of the study's CFI is 0.957.

F_0 incorporates no penalty for model complexity and will tend to favor models with many parameters. In comparing two nested models, F_0 will never favor the simpler model. Steiger and Lind [51] suggested compensating for the effect of model complexity by dividing F_0 by the number of degrees of freedom for testing the model. Taking the square root of the resulting ratio gives the population "root mean square error of approximation", called RMS by Steiger and Lind [51], and RMSEA by Browne and Cudeck [52]

$$\text{Population RMSEA} = \sqrt{\frac{F_0}{d}} \tag{7}$$

Table 4
Path coefficients and their significance values.

Path	Standardized coefficients	S.E.	C.R.	*P*
Consumer intention < —Price	0.527	0.135	3.402	0.0**
Consumer intention < —Policy and government incentives	0.304	0.146	2.036	0.042*
Consumer intention < —Quality	0.170	0.050	3.365	0.0**
Quality < —policy and government incentives	0.161	0.073	2.177	0.029*
Price < —policy and government incentives	0.872	0.081	12.161	0.0**

* Significance at $p < 0.05$ level.
** Significance at $p < 0.01$ level.

$$\text{Estimated RMSEA} = \sqrt{\frac{\widehat{F}_0}{d}} \tag{8}$$

The results show that the RMSEA index is 0.087.

Overall, our model exhibited a reasonable fit with the data collected. We assessed the model fit using other common fit indices, such as the Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Normed Fit Index (NFI), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA). The model exhibited a fit value exceeding or close to the commonly recommended threshold for the respective indices, the commonly suggested in Table 3.

4.3. Construct reliability analysis

The construct reliability means that a set of latent indicators of constructs are consistent in their measurement [50]. If the construct reliability is higher than 0.7, the quality of the structural equations model is considered acceptable [51]. The author will use the model standardized regression weights to calculate the construct reliability, presented as ρ_c. Construct reliability of quality, price, consumer intention, policy and government incentives was calculated at a suggested lower limit of 0.70 with Eq. (9). The results have been shown in Table 2

$$\rho_{c1} = \left[\frac{(\Sigma\lambda_1)^2}{(\Sigma\lambda_1)^2 + \Sigma\theta_1}\right] \tag{9}$$

Another index, similar to construct reliability, is "Average Variance Extracted (AVE)," presented as ρ_v. This index can explain how much variance explained in the latent variable comes from the observed variables.

The higher the average variance extracted, the better the observed variables could explain the latent variable. Generally speaking, the model's quality is considered good when the average variance extracted is higher than 0.5 [53]. The average variance extracted from quality, price, consumer intention, policy and government incentives was calculated at a suggested lower limit of 0.50 with Eq. (10). The results have been shown in Table 2

$$\rho_{v1} = \left[\frac{(\Sigma\lambda_1^2)}{(\Sigma\lambda_1^2) + \Sigma\theta_1}\right] \tag{10}$$

4.4. Results of hypothesis testing

After establishing an acceptable measurement model, we evaluated the structural model shown in a path diagram in Fig. 2. Their path coefficients and their significance values are reported in Table 4. The results of the SEM analysis show that H1–H5 were supported.

To test the statistical significance of the parameter estimates from SEM, the test statistic is the Critical Value (C.R.), which represents the parameter estimate divided by its Standard Error (S.E.). Based on a significance level of 0.05, the C.R. needs to be $> \pm 1.96$; based on a significance level of 0.01, the C.R. needs to be $> \pm 2.576$ [54]. These significance values between price and consumer intention; between quality and consumer intention; between price and policy-government incentives (Table 3) were significant at level of 0.01. These significance values between consumer intention and policy and government incentives as well as between quality and policy-government incentives (Table 4) were significant at level of 0.05. The first column in Table 4 expresses the influence degree of each in dependent variable for the dependent variable.

The result shows that price, quality, policy and government incentives can affect consumer purchasing intention in diesel consumption. The factor of price has the largest influence in these factors (0.527). The second most important one is policy and government incentives (0.304) and the last one is quality (0.17). In addition, policy and government incentives may affect the biodiesel's quality (0.161) and price (0.872). The results of hypothesis testing express that the price of biodiesel has the highest influence compared with policy and government incentives as well as quality for consumers to adopt biodiesel. Because China is a developing country and most diesel car drivers are low-income groups., the price of fuel is the preferential issue when drivers choose their daily fuel. Besides, policy and government incentives to price have high coefficient (0.872). The reason of this result is that China is a country with strong policy guidance. The policy issue could strongly affect the price of biodiesel.

5. Conclusion

With China's rapid economic development and high oil prices, the supply of diesel is kind of inadequate in China. In addition, promoting biodiesel implementation in transportation is an important strategy to enhance energy security and lower the emission of green-house gas in China [21]. Therefore, all of these provided a good opportunity to the development of biodiesel. In conclusion, some significant findings and suggestions have been reached in this paper as follows:

- In light of the results of the investigation, policy and government incentives are able to influence the price of biodiesel. Besides, price is a very important factor when drivers of private diesel vehicle select fuels. Since the transportation expense occupies a large part in household expenditure in China, therefore, appropriate policies are necessary to regulate price to promote the biodiesel market.
- The policy and government incentives will increase consumers' confidence of biodiesel and the quantity of private diesel vehicle owners. Nowadays, policies publicizing biodiesel are still scarce. Moreover, the existing policies and incentive plans could not provide practical guidance. Therefore, the government had better take effective measures, such as regulating the quantity of public procurement, providing massive subsidies and tax exemption for consumers. In addition, certain departments are required to be responsible for the effective implementation of these policies. By

doing that, the biodiesel market can be further expanded through government incentives.

- As is shown in the results of the survey, most drivers care about the quality of biodiesel. In order to meet consumers' needs, more attention should be paid to improve the quality standard of biodiesel. Currently, the key techniques and equipment of biodiesel production has not been broken through and the authoritative quality standard in China has not been complete. Therefore, it is necessary for the government and biodiesel corporations to increase input on the R&D of biodiesel technology, which means greater performance and less pollution. Furthermore, the government should take action to study, establish, revise and improve the national standard for biodiesels B5, B10, B20 and provide related rules and regulations.

Compared with other research on biodiesel application in China, this paper investigates the issues of biodiesel implementation from the perspective of consumers' attitude, which provides a new approach for improving the biodiesel implementation in China. In the future, we plan to carry out investigation covering more representative samples in China. Moreover, more factors that would influence consumers' acceptance of biodiesel will be taken into consideration. And more methods would be used to analyze the consumers' biodiesel consumption behavior.

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